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MESSAGES IN MORSE FROM MARS

By P. E. Cleator

While I do not here presume to question the mental well-being of those (including myself) who profess an intelligent interest in space travel and its possibilities, it nevertheless remains a curious and no doubt significant fact that the interplanetary idea has a seemingly irresistible fascination for the somewhat crack-brained, the near demented, and the hopelessly insane. Ever since the day I first ventured to proclaim the unique merits of propulsion by rocket, and thereby earned for myself the reputation of being a harmless lunatic on my own account, I have been assailed by hordes of frustrated and would-be geniuses, each and every one with some bee or other in his or her bonnet, and full of the glad tidings that the circle can be squared, or that twice two is five, or that the Earth is flat, or that Mark xvi. 17–18 actually means what it says, or that the Moon boasts an atmosphere, or that space is infinite, but finite. . . .

That these vociferous imbeciles should take it upon themselves to write to me is a fact that I regard with no undue equanimity. What gives them the idea that I am likely to regard their pet nonsense as anything but nonsense? And where, or from whom, do they contrive to obtain my address? Heaven alone knows. But their letters and their pamphlets and their treatises and their tracts have been descending upon me for years, to the never-ending despair of the luckless postman who daily brings them in, and the torrid imprecations of the refuse collector who prayerfully carts them out. It is a dull week, indeed, which does not produce a letter of enquiry about the Society from a hopeful inmate of an asylum, or a ream of typewritten gibberish from an unfettered half-wit on the loose in Chicago, or a formal announcement from some prize specimen of *Homo Biblicus* that the Second Coming, now nearly two millennia overdue, is about to burst upon the world at last —heralded by the arrival of a rocket of 5,000 angel power, manned and guided by 40 head of ex-terrestrial bishop.

Do I hear it suggested that I tend to exaggerate? Or even that I spoof? Then I offer for consideration a typical, everyday example—the case of the lady who believed herself to be receiving cryptic messages of hope and enlightenment from intelligent beings resident on Mars. Word of the phenomenon first reached me from New Zealand, in a letter consigned to me personally by the recipient of the phantom messages herself. As a hardened sinner and a complete sceptic in matters spiritual and occult, I received the news with some reserve.

But as a dutiful member of polite society, I duly despatched a brief note of acknowledgment and thanks. This escritorial gallantry, it soon became evident, was a grave tactical error, for my letter was at once taken for encouragement, and as an open invitation for more. Promptly, a seemingly endless stream of messages, relayed to me *via* New Zealand, began to pour in from Mars.

Here let me anticipate your natural curiosity by stating that, at this late date, the purport of these messages is lost beyond recall, at least in so far as I myself am concerned. Due to an overt act of God, my old home became the target for an outsize bomb early in 1941, and the entire establishment, its occupants and its contents, incontinently preceded me to Hell. With all my private correspondence files thus destroyed, I am completely at a loss, for my memory fails me lamentably in the matter: I honestly do not remember a single thing that the alleged Martians supposedly said.

I recollect, however, that one day there arrived a familiar envelope addressed in a familiar scrawl—but with an English stamp! Yes; the relay service herself was on a visit to these Isles. And, yes, she most urgently desired to see me. At the time, I was in the midst of planning a motor trip which would take me almost to her door, and in the face of so providential a circumstance I replied with a promise to call. And so, in strict accord with divine whim, we at last came face to face.

She was not at all as I had pictured her. With or without just cause, I had envisaged an otiose dilettante, with a thirst for astrology, spiritualism, religion, the reading of tea cups, and other such popular quackeries. Instead, I found an elderly lady of frail build, surprisingly alert mentally for her age, and undeniably endowed with no little intelligence. Could this charming old soul be the inventress of all those bogus communications from Mars? The question was no sooner posed mentally than it was answered verbally, for at once I was swept off my feet and carried far out to sea by an overwhelming flood of metaphysical verbiage. To this day I do not know what the woman gabbled about. And to this day I do not care. . . .

After a couple of hours of sustained incomprehensibility, I began to pick out a word or two, and towards the end I found myself able to understand whole sentences. With the passing of the years, it appeared, there had come to her the realisation that she could not hope to complete her life's work. And so she was searching for someone to carry on with the vital task—someone with youth on his side, someone endowed with a deep interest in matters astronomical, someone . . .

I declined the invitation, of course, gently at first, and with as much grace as I could muster. But my refusal was put down to undue modesty, and lightly brushed aside. In the end, I was compelled to insist that my rejection of the offer was based, not on any restraining sense of propriety, but on the very good grounds that I did not believe a word of the confounded business. This heresy plainly shook her, and it was evident that she was both hurt and disappointed. Well, she is now at peace in the Christian Valhalla, happily communing, I dare say, with the ghostly inmates of some remote and improbable Martian heaven, and I call upon all the high gods concerned to bear witness that I tried to let her down as lightly as possible.

GENERAL MOTION OF A ROCKET IN A GRAVITATIONAL FIELD

By Derek F. Lawden, M.A.

In previous articles, equations have been derived describing the motion of a rocket ascending vertically from the surface of a body "fixed" in space. The partition of the latent energy of the fuel between the rocket proper and the exhaust gases was discussed and it was concluded that there was maximum energy transfer to the ship when the initial acceleration was at its greatest. The conditions of vertical ascent and zero initial velocity in space will now be relaxed so that more general equations of the rocket's motion may be obtained. This motion will no longer be assumed rectilinear, but will be taken to follow, in general, some twisted trajectory in space. It will be found convenient to economise in symbols and space by using vector notation, and then scalar products of vectors will be denoted by a dot, e.g. $\boldsymbol{a} \cdot \boldsymbol{b}$.

Let v be the velocity of the rocket at time t.

$\mathbf{U}$ be the exhaust velocity relative to axes moving with the rocket, but not rotating.

m be the mass of the rocket at time t, m_0 its initial mass at $t = t_0$ and m_1 its final mass at $t = t_1$.

V be the potential of the attracting body's field.

Then the rocket's equation of motion is well known to be:—

$$\frac{d\boldsymbol{v}}{dt} - \frac{\mathbf{U}}{u}\frac{dm}{dt} = -\,\text{grad. V} \quad .. \quad .. \quad .. \quad (1)$$

Taking the scalar product of both sides with v we have:—

$$\boldsymbol{v} \cdot \frac{d\boldsymbol{v}}{dt} - \frac{\boldsymbol{v} \cdot \mathbf{U}}{m}\frac{dm}{dt} = -\,\boldsymbol{v} \cdot \text{grad. V}$$

$$\text{or} \quad \frac{d}{dt}\left(\tfrac{1}{2}\boldsymbol{v}^2\right) - \frac{\boldsymbol{v} \cdot \mathbf{U}}{m}\frac{dm}{dt} = -\frac{d\text{V}}{dt}$$

This may be written:—

$$\frac{d}{dt}\left(\tfrac{1}{2}\boldsymbol{v}^2 + \text{V}\right) = \boldsymbol{v} \cdot \mathbf{U}\frac{dw}{dt} \quad .. \quad .. \quad .. \quad (2)$$

where $w = \log m$.

But $(\frac{1}{2}\boldsymbol{v}^2 + \text{V})$ is the total energy per unit mass of the rocket and is therefore the quantity which must be raised above a certain minimum if the rocket is to escape from the gravitational field. Equation (2) shows that for given magnitudes of $\boldsymbol{v}$, $\mathbf{U}$ and dw/dt the rate of increase of this quantity is greatest when $\boldsymbol{v}$ and $\mathbf{U}$ are parallel, for then the scalar product takes its maximum value. It is therefore desirable, in the interest of maximum energy transfer to the rocket, that the jet shall always be directed in a direction opposite to v. Since the point of projection inevitably possesses a velocity tangential to the surface of the body of departure (unless it is intended to launch the ship from one of the poles—an unlikely proceeding), this statement carries with it the

implication that initially the jet should also be directed along this surface and thereafter maintained in a direction tangential to the trajectory. This is in accordance with expectations, but there are two observations to be made. Firstly, this mode of departure involves maximum air resistance, since the rocket will cleave the atmospheric belt obliquely. Secondly, without lifting surfaces, since the motor thrust is in a direction at right-angles to gravity, the curvature of the trajectory would be too great initially and it would not clear the Earth's surface. It is therefore to be expected that the line of departure will make some non-zero angle with the horizontal so that for the first few seconds of thrust $\boldsymbol{v}$ and $\mathbf{U}$ will not be parallel. Parallelism should then be restored at the earliest possible moment. If these conclusions are agreed to it will be necessary to devise an instrument capable of measuring the angle between these two vectors and preferably of taking automatic action by switching on of side jets when lack of parallelism is observed.

By a method precisely similar to that adopted for the case of rectilineal motion it may be shown that E, the energy injected into the system from the fuel, at time t, is given by:—

$$\frac{d\mathrm{E}}{dt} = -\tfrac{1}{2}\,\mathbf{U}^2\,\frac{dm}{dt} \quad .. \quad .. \quad .. \quad .. \quad (3)$$

and, again, as in the simpler case, it is deduced that $\mathbf{U}^2$ is constant, i.e. the magnitude of the exhaust velocity is steady.

Integrating (2) with respect to t gives:—

$$\tfrac{1}{2}\boldsymbol{v}_1^2 + \mathrm{V}_1 = \tfrac{1}{2}\boldsymbol{v}_0^2 + \mathrm{V}_0 + \int_{w_0}^{w_1} \boldsymbol{v}\cdot\mathbf{U}\,dw \quad .. \quad .. \quad (4)$$

where $w_0 = \log m_0$ and $w_1 = \log m_1$.

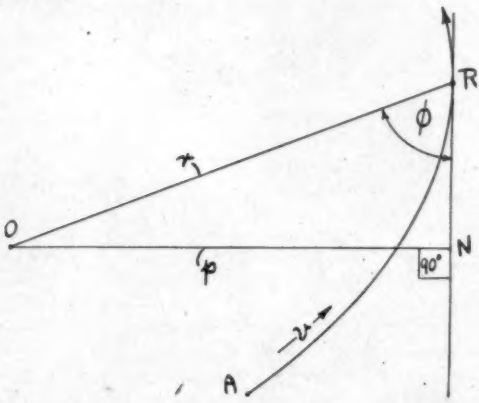

FIG. 1.

If the initial and final masses are fixed, so is the interval of integration. The magnitude of U is steady, being fixed by the fuel and conditions of combustion, and so the integral takes its maximum value if the magnitude of the

velocity v for any given w is as large as possible. It follows that in this more general case also, the acceleration must be as large as possible if the final total energy is to be a maximum.

It will be assumed, then, that the direction of the jet is tangential to the trajectory and that the fuel is burnt so as to maintain the acceleration along the trajectory constant, at ng. The first assumption implies that the trajectory will lie in a plane, which simplifies the problem enormously.

The attraction of the body at a point distant r from its centre O is ga^2/r^2, where a is its radius. Let ϕ be the angle between the radius vector r, from O to the rocket R, and the tangent to the trajectory. Let p be the perpendicular from O on to this tangent (see Fig. 1).

Let s be the distance along the trajectory from the point of projection A. Then resolving equation (2) along the tangent and normal to the curve at R gives

$$\frac{dv}{dt} + \frac{U}{m}\frac{dm}{dt} = -\frac{ga^2}{r^2}\cos\phi = -\frac{ga^2}{r^2}\frac{dr}{ds} \quad .. \quad .. \quad (5)$$

$$\frac{v^2}{\rho} = \frac{ga^2}{r^2}\sin\phi = \frac{ga^2p}{r^3} \quad .. \quad .. \quad .. \quad (6)$$

where ρ is the radius of curvature of the path.

Controlling the rate of burning so that

$$\frac{U}{m}\frac{dm}{dt} = -ng \quad .. \quad .. \quad .. \quad .. \quad (7)$$

maintains the acceleration experienced by the crew constant and allow (5) to be written:—

$$v\frac{dv}{ds} + ng = -\frac{ga^2}{r^2}\frac{dr}{ds}$$

Integrating with respect to s gives:—

$$\tfrac{1}{2}v^2 + ngs = \frac{ga^2}{r} + \tfrac{1}{2}v_0^2 - ga \quad .. \quad .. \quad .. \quad (8)$$

Now $\rho = r\,dr/dp$ and so (6) gives

$$v^2 = \frac{ga^2p}{r^2}\frac{dr}{dp} \quad .. \quad .. \quad .. \quad .. \quad (9)$$

Elimination of v^2 between (8) and (9) gives

$$\frac{dr}{dp} = \frac{2r}{ga^2p}(ga^2 + \tfrac{1}{2}v_0^2r - gar - ngsr) \quad .. \quad .. \quad (10)$$

which, together with

$$\frac{dr}{ds} = \left(1 - \frac{p^2}{r^2}\right)^{\frac{1}{2}} \quad .. \quad .. \quad .. \quad .. \quad (11)$$

a geometrical relationship, defines the trajectory.

The author has been unable to obtain an exact solution of (10) and (11) and very much doubts whether a solution in terms of the known functions

exists. Assuming constant gravitational attraction does little to simplify them and so numerical methods must be used. Integration of the equations by such methods would be laborious but not very difficult, and it would be interesting to know the form the trajectory takes for different velocities and angles of departure at the Earth's surface relative to axes fixed in space. With the cessation of thrust the rocket would commence to orbit along one arm of a hyperbola, eventually travelling in a straight line at constant speed along an asymptote. Knowing the direction and magnitude of the velocity to be attained when the space ship has escaped from the gravitational attraction, the use of charts, showing numbers of possible trajectories of departure, in the manner described below, would permit the rapid selection of a suitable trajectory, which could then be calculated to a high degree of accuracy. It is the author's opinion that work of this character might usefully be undertaken by the appropriate technical section of the Society.

The problem of best approach to an attracting body on which it is desired to make a landing is similar to the problem of departure and may be solved in general terms by consideration of equation (4). Given the velocity $\boldsymbol{v}_0$ and the potential V_0 of the rocket at some point of its trajectory of approach, the problem is to determine the most economical manner of retarding the free fall by use of the jet alone, so that when the rocket has fallen to a potential V_1 at the surface of the body, its velocity is $\boldsymbol{v}_1$, equal to the velocity of the surface at this point. The interval of integration (w_0, w_1) must be made as small as possible and the first step is therefore to make $\boldsymbol{v}_1$ as large as possible, i.e., the landing should be effected on the equator. All terms but the integral of (4) are now fixed and hence the value of this integral is specified. If the interval (w_0, w_1) is to be as small as possible, the integrand $\boldsymbol{v} \cdot \mathbf{U}$ must be as large as possible at all times. This can be done firstly by maintaining $\mathbf{U}$ consistently parallel to $\boldsymbol{v}_1$ and secondly, by allowing free fall towards the body for as long a period as possible so that $\boldsymbol{v}$ is as large as possible over the interval of integration. In practice it is impossible to realise all these conditions; the final retardation cannot be too large and the orbit for which $\boldsymbol{v}$ is parallel to $\mathbf{U}$ and $\boldsymbol{v} = \boldsymbol{v}_1$ at the body's surface, intersects this surface. The above conditions must be approximated to as nearly as possible. It is easily seen that the trajectories of approach are identical with the trajectories of departure already discussed, the direction of description alone being reversed.

A number of charts might be drawn up, each corresponding to a particular velocity of arrival or departure at the surface of the attracting body. The orbits corresponding to various angles of approach or departure at this velocity would be drawn in, as shown in Fig. 2, points of equal velocity being connected by equi-velocity curves. Along the orbits would be plotted a time scale and a mass ratio scale. The curves need be drawn for one point of departure or arrival only, since there is spherical symmetry. The utilisation of such a set of charts is a matter for further study, but it should be possible to devise a fairly simple drill. For example, the chart might be pivoted at its centre O, beneath a ground glass panel through which the orbits would be clearly visible. The free orbit under the gravitational attraction of the body alone would be

plotted to the same scale as the chart on the panel, the exact orientation being immaterial, and values of the velocity at various points along this orbit calculated and entered on the trace. This calculation presents no difficulties, the formulae being well known. By rotation of the chart the various orbits of arrival could now be orientated one at a time to be tangential to the free orbit. The orbit of arrival for which the velocity at its point of contact with the free orbit agreed with the velocity for the free orbit at this point would constitute a possible trajectory of approach.

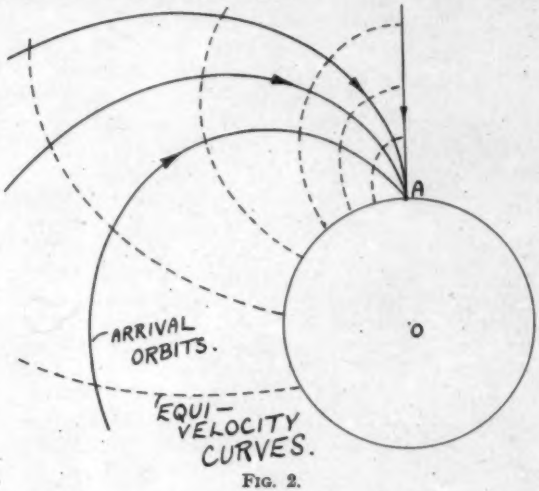

FIG. 2.

Repeating this procedure for different velocities at the point of arrival A, (relative to fixed axes, of course, not relative to the body's surface, since this velocity depends on the orientation of the figure), the most suitable trajectory of approach could be picked out.

Until the time comes to draw up such charts for an actual space ship, values of n and U will have to be assumed, e.g., $n = 5$, U = 10 km./sec., though it will be noted that the shape of the trajectories for a given body depends only on n. The value of U fixes the mass ratio scale. In the case of the Earth or any other body with an atmosphere it will be convenient to take A outside the atmospheric belt, the final part of the orbit being dealt with separately.

American Rocket-Testing Range

Some details have appeared of an American rocket-testing range comparable to the projected Anglo-Australian one. The American proposal is for a firing point at El Centro, California, near the Mexican frontier and 100 miles east of San Diego. The rockets would travel 800 miles down the Gulf of California, or even farther out into the Pacific Ocean. At the moment, the agreement of the Mexican Government to the scheme is being sought.

TECHNICAL NOTES ON GERMAN ROCKET DEVELOPMENT—3

By Eric Burgess

At the close of hostilities there were various types of aircraft booster and assisted take-off units being developed by the Germans, but these could be divided into two main classes. The first class consisted of those rocket boosters which employed a solid fuel propellant, the most popular of which appeared to be a fuel known as diglycol-dinitrate. This fuel was moulded into steel cylinders and gave a specific impulse of approximately 167 sec., which means that the specific fuel consumption amounted to 5·9 grms. per kgm./sec. (21·2 lbs. per lb. thrust/hour). There were reports, however, that this fuel was not too successful and that difficulties were experienced in the use of solid fuel booster rockets for assisted take-off of the rocket-propelled aircraft which were being developed.

The other class of boosters, which consisted of those utilising liquid fuels, appeared to be much more successful, and these were used on such aircraft as the He.111, He.177, Ju.88, BV.138, Do.18 and Me.321. The rockets were designed to fit snugly into streamlined nacelles slung underneath the wings of the aircraft, so that when the fuel was exhausted they could be jettisoned and brought to earth safely by parachute, to be re-fuelled and used again.

Principally, these units were developed by Walter at Kiel, and they employed the normal Walter "cold" cycle in which hydrogen peroxide was broken down by the action of calcium or sodium permanganate to produce a mixture of superheated steam and oxygen at a temperature of about 480° C. These gases formed the efflux from the reaction chamber and produced a specific impulse of approximately 100 secs., thus implying a specific fuel consumption of 9·3 grms. per kgm./sec. (33·5 lbs. per lb. thrust/hour).

A special design of reaction chamber was used in which the hydrogen peroxide was sprayed on to a flow reversal burner cup, and spiral guide vanes were used to increase the effective length of the reaction chamber and thus assist in the obtaining of a more complete reaction. The first of these motors was the 109–500 unit, which developed a thrust of 500 kgm. It employed compressed air to displace the fuels (T-stoff and Z-stoff) from the tanks into the steel reaction chamber. The air was stored in five steel pressure bottles at 150 atmospheres, but this pressure was reduced through the normal type of reducing valve before being applied to the tanks. Control of the unit was effected by means of solenoid and pressure valves.

Subsequent units, known as the 109–501 and 109–502 boosters, employed a mixture of hydrazine hydrate and gasoline (Br + B-stoff) in order to increase the specific impulse. The chambers of these later units were fuel-cooled and an increased specific impulse of 180 secs. was obtained, while the specific fuel consumption was reduced to 5·48 grm. per kgm./sec. (19.6 lbs. per lb. thrust/hour).

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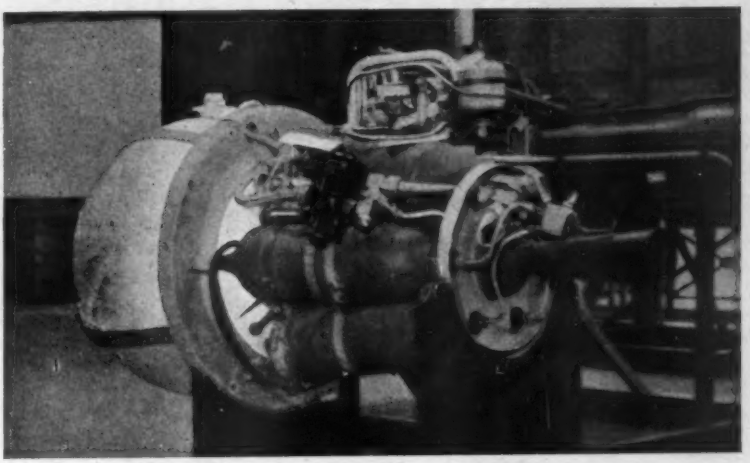
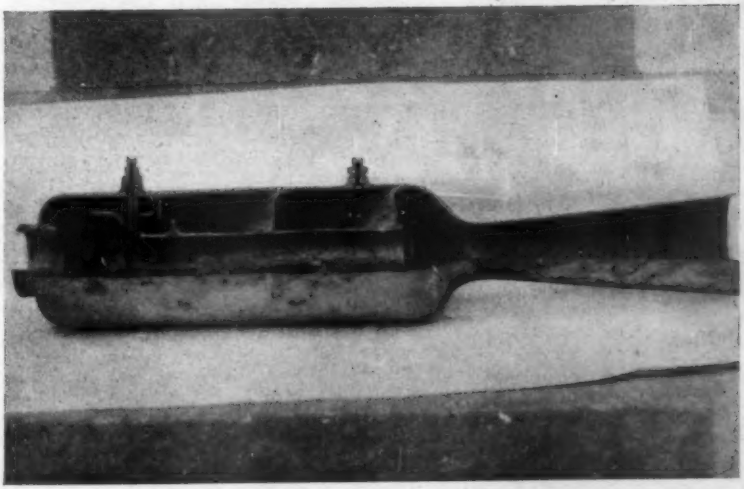


HWK 109–500 A.T.O. Bi-Fuel Unit.



Reaction Chamber of HWK 109–500 Unit.

Details of the characteristics of several diglycol and liquid fuel units are given in the table.

DIGLYCOL AND LIQUID FUEL UNITS

R.L.M. designation.	Fuel. Type.	Fuel. Weight kgm.	Fuel. Feed.	Thrust kgm.	Duration secs.	Specific impulse secs.	Dimensions (cms.). Length.	Dimensions (cms.). Diameter.
Walter 109–500	T Z	130·0 6·6	Compressed air	500	30	103	145	68·5
Walter 109–501	T Z Br + B	221·5 10·8 17·4	Compressed air	1,000	42·5	170	183	83·5
Walter 109–502	T Z Br + B	221·5 10·8 17·4	Compressed air	1,500	30	180	183	83·5
Walter 109–509 S1	T C	—	Turbo-pump	2,000	—	180	250 (approx.)	95·0 (approx.)
Rheinmetal-Borsig 109–515	Diglycol-dinitrate	34·6	—	1,000	6	182	224	17·5
Schmidding 109–533	Diglycol-dinitrate	65·0	—	1,000	12	182	—	—
Schmidding 109–553	Diglycol-dinitrate	40·0	—	1,750	4	182	237	16·8
Schmidding 109–563	Diglycol-dinitrate	17·0	—	500	6	182	99	16·8
Schmidding 109–593	Diglycol-dinitrate	17·0	—	750	4	182	99	16·8
B.M.W. 109–718	SV R	130·0 516·0	Pump from turbine shaft	1,250	120	177	120 (approx.)	30·0 (approx.)

Diglycol-dinitrate.—Standard WASAG R61, consisted of: Nitrocellulose (12·2 per cent. N_2) 61·5 per cent., diethylene glycol-dinitrate ($C_4H_8N_2O_7$) 34 per cent., ethyl phenyl urethane ($C_{11}H_{15}NO_2$) 1·4 per cent., diphenyl urethane ($C_{13}H_{11}NO_2$) 2·2 per cent., water ·9 per cent.

THE ATMOSPHERE OF VENUS

By SHEILA M. MATHER

When Venus appears as a crescent, her disc may be seen partially outlined by the "horns," which indicates that areas of twilight exist, and this, together with the planet's very high albedo, points to the existence of an atmosphere probably both dense and cloud-filled.

The close similarity between the Earth and Venus, in both size and mass, led, until recently, to a natural but mistaken idea that the two planets had the same type of atmosphere, and that the vast cloud-masses which obscure the surface of Venus at all times were composed of water-vapour, like the clouds in our own atmosphere.

Recent advances in the technique of spectroscopy and photography in light of different colours have, however, proved beyond all doubt that whatever, in fact, the atmospheric conditions of Venus may be, they in no way resemble our own.

Photography in the infra-red, red, and blue having proved unsuccessful, ultra-violet light was then tried by Ross, at Mount Wilson. This gave better

results than light of the longer wavelength, as the movement and formation of the clouds could then be seen, swinging across the planet in parallel bands, dark or bright in accordance with their position low or high in the atmosphere.*

Spectrograms of Venus made by Adams and Dunham,[1] indicating certain strong absorptions in the infra-red, were shown by Dunham† to prove the presence of large quantities of carbon dioxide in the outer layers of the planet's atmosphere—as much as two miles at standard (sea-level) pressure being estimated by Adel and Slipher.[2] No traces were found, however, of either oxygen or water-vapour, this ruling out the suggestion that the atmospheres of the Earth and Venus are similar and that the cloud-masses of the latter are composed of water droplets.

The question thus arises, of what substances are these clouds formed? The close proximity of Venus to the Sun (which gives her a recorded temperature of approximately 50–60° C. on the side facing the Sun, dropping to about − 20° C. at the dark side, according to the measurements of Pettit and Nicholson,[3]‡) the heat-absorbing properties of an atmosphere heavily charged with carbon dioxide, combined with the apparently complete absence of water-vapour, seems to point to Venus as a dry planet, devoid of oceans or lakes—perhaps of all water (although there might still be some at the surface, undetected because of its scarcity), heated like a greenhouse and possibly surrounded by a continual storm of dust raised from her deserts.

This view, however, is by no means the only one that can be taken, and Rupert Wildt of Princeton put forward a hypothesis[4] which suggested that the clouds may be composed, not of dust, but of a plastic form of formaldehyde. His reasons for this were that where there is a mixture of carbon dioxide and water-vapour, and there is sufficient ultra-violet light to provide the energy for the photochemical reaction, formaldehyde will be produced, releasing free oxygen at the same time. The formula for this reaction is $CO_2 + H_2O \rightarrow CH_2O + O_2$. This involves the supposition that such water as there was in the planet's atmosphere, has now been all, or practically all, removed by the process, in which case the reaction would now be prevented from continuing. This would also mean that there could have been little oxygen since the earliest times, a fact conducive to the presence of a large amount of ultra-violet radiation, to which oxygen forms a heavy barrier, while carbon dioxide offers no resistance.

Formaldehyde is a colourless gas until mixed with water-vapour, which causes polymerisation to take place, and the resultant molecular chains form thick clouds of polyoxymethylene hydrates in the form of droplets. Wildt

* *Differences in opacity of these clouds when observed in the ultra-violet may be due to variations in their chemical constituents.*

† *Dunham's method of proof in this case was to fill a pipe 40 metres long with CO_2 at a pressure of about 10 atmospheres, and then compare the spectrograms taken from the light passed through this with those of Venus.*

‡ *The small difference between "day" and "night" temperatures is one of the few indications we have of the rotation of Venus. If the planet did not rotate, but always kept the same face to the sun, the difference would be much greater, and the temperatures much more extreme. The movements of the clouds furnish another such indication, although the exact period of rotation is at present unknown.*

mentions that this may have been the reason why spectrograms of Venus showed no signs of formaldehyde, as it would show as absorption bands in the spectrum only in a gaseous form, and the temperatures at which it vaporises are extremely high. The melting point of polyoxymethylene hydrates is 140–170° C.—too high to be found in the upper layers of Venus's atmosphere.

A difficulty which arises here lies in the disposal of the oxygen set free at the time of the formation of the formaldehyde. Unless this was removed it would eventually stop the photochemical reaction by its "blanketing" effect against the ultra-violet radiation, though, as Wildt pointed out, this would be overcome by the general progress of "weathering" on the surface of the planet, by which process the free oxygen would become bound up.

In regard to the actual surface of Venus under these supposed conditions, Wildt thought that if all the water-vapour in the atmosphere had now been used up, this may have been covered with the solid polyoxymethylene hydrates, or "formaldehyde snow."

Since putting forward this theory, however, Wildt has published a further paper[5] in which he repudiates it, due to some hitherto unpublished data on certain experiments by Dr. J. F. Walker, in which the latter had shown that there would be a certain amount of simple formaldehyde in the vapours in equilibrium with the polyoxymethylene hydrates produced by photochemical synthesis. To Wildt this seems to disprove his former theory, as in such case some signs of formaldehyde ought to show spectroscopically. It is possible, however, as Sir H. Spencer Jones points out,[6] that more light could be thrown on Wildt's original hypothesis by comparing the polarisation-phase curve for Venus with that of polyoxymethylene hydrates, in accordance with the method used by Lyot.[7]

It will be seen that there is a wide field for speculation here, and further research into the question of the planet's atmosphere is greatly to be desired, especially now that the apparent destruction of the only theory that seemed to fit the known facts has made the position one of total uncertainty.

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(7) Lyot. *Revue d'Optique*, **5**, 108, 1926.

WANTED.—*Rockets Through Space* (Cleator). S. W. Greenwood, 27, Clifton Street, St. Albans, Herts.

WANTED.—Old copies of B.I.S. *Journals*, *Bulletins* and other material on rockets and space travel. Will purchase or exchange. M. Edward Peck, 214, Lynnwood, Lincoln Heights, Jeffersonville, Ind., U.S.A.

FOR SALE.—Copy of *I Viaggi Interplanetari* (The Interplanetary Travels by the Solar Radiation), by L. Gussalli. Italian, with English translation. 5s. Box 1, c/o B.I.S.

THE REACTION MOTORS MODEL 6000C4 ROCKET ENGINE*

The Reaction Motors Model 6000C4 rocket engine is a rocket power plant designed to propel piloted aircraft at velocities greater than the speed of sound. The engine was developed through close co-operation of R.M.I. with the American Services, and it is the final product of extensive research and experimentation. The first practical application of the power of the 6000C4 is in the Army's experimental supersonic aeroplane, the Bell XS-1.

The relatively small, highly powerful unit may be defined briefly as a liquid propellant regenerative rocket engine which develops almost instantaneous total thrust upwards of 6,000 lbs., or fractions of total thrust in increments of 1,500 lbs. In contrast to the high output of the engine are its relatively low weight and small size. Its total weight is 210 lbs. and it occupies a space of approximately 19 inches diameter by 56 inches long, which provides a compact installation in the XS-1. In addition to its compactness is also its ease of installation in aircraft, requiring but a matter of a few minutes. The only connections that need be made consist of attaching the engine to the airframe at four mounting points, attaching the two propellant feed lines to the manifold inlets on the engine, and connecting the electric lead wires into a standard socket on the engine control box.

The engine consists basically of four combustion cylinders plus all the necessary piping, wiring and controls, supported by a single main beam assembly. With minor exceptions such as piping, wiring and the control box, the entire unit is constructed of high-grade, stainless steel. The major components of the engine are almost entirely of welded construction. Fig. 1 shows the schematic construction of a typical combustion cylinder. The engine

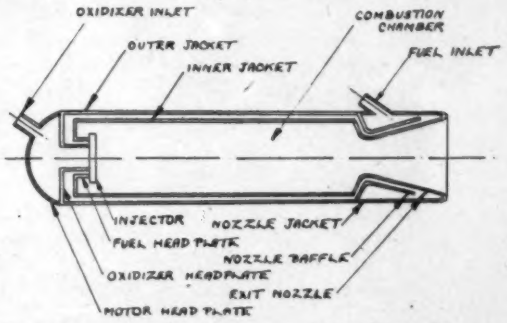

FIG. 1. Schematic construction of a typical liquid propellant regenerative rocket engine cylinder.

operates from the controlled combustion of a fuel and an oxidiser. An alcohol-water mixture is the fuel, and liquid oxygen is the oxidiser. These propellants

* Condensed from an article by Lovell Lawrence, Junr., President of Reaction Motors, Inc.

are injected under pressure into a combustion chamber where they are thoroughly mixed and ignited. The rearward expulsion of the combustion products through the nozzle in the form of a jet of hot gas develops the forward thrust.

The major components of the engine are: the main support beam, the control box, the propellant manifolds (fuel and oxygen), the propellant valves (of which there are two types—fuel and oxygen), the igniters and the combustion cylinders (see Fig. 2). The main beam assembly, as its name implies, is provided to support all the other components as a single unit.

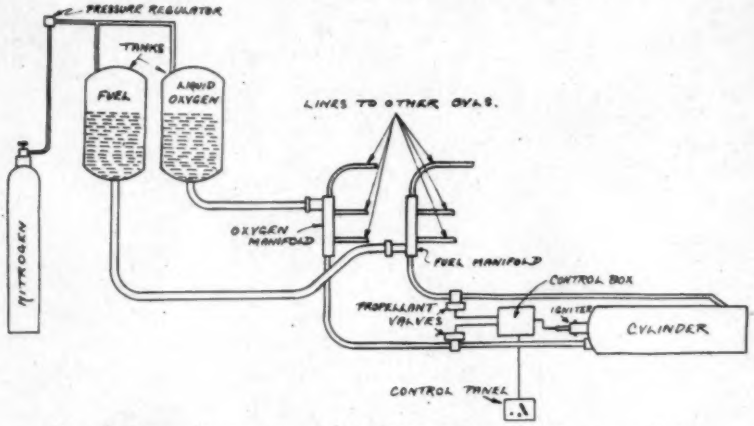

FIG. 2. Schematic flow diagram of 6000C4 engine, showing one cylinder.

All phases of the operation of the complete power plant are actually regulated by the "master-mind" control box. The fuel and oxidiser enter the propellant manifolds from their pressurised tanks. With their pressure regulated by the propellant valves, the propellants flow to the combustion cylinder where they are mixed in the injector and sprayed into the combustion chamber. The igniter, itself a miniature rocket motor, sets off the mixture and the resulting mass of hot gases forces itself out through the exhaust nozzle with a terrifying roar and at tremendous velocities in the neighbourhood of 6,500 feet per second.

The combustion in the rocket motor takes place in the combustion chamber at a very high pressure, and because of this, as well as because of the energetic nature of the propellants used, a rocket motor develops intense heat (4,500–5,000° F.) on the combustion cylinder walls. To offset this, the combustion cylinders of the 6000C4 are so designed that the liquid fuel, before entering the combustion chamber, passes between the inner and outer cylinders (see Fig. 1). The fuel cools the walls and in turn the heat from the walls tends to evaporate the fuel before it is injected into the combustion chamber. This principle is known as regenerative cooling, because the heat absorbed by the fuel is returned to the combustion chamber. This method of cooling

is so effective that the stainless steel nozzle and combustion wall do not suffer any erosion or over-heating even after several hours of operation. The external tenperature of the cylinders rarely exceeds 140° F.

Since alcohol and liquid oxygen do not ignite spontaneously, an igniter has been developed to initiate the combustion. The igniter is a very small rocket motor attached to the head of each combustion cylinder. It is fed the same propellants as the main combustion chamber, is started with a spark plug, and may be turned on or off at will.

One of the requirements in designing this engine was that it should be capable of repeated starts and stops in various attitudes, including firing with the nozzles pointing 30° upwards. In order to comply with these requirements, a special injector had to be developed. This difficulty overcome, the engine can now be started easily in any position. In fact, positive ignition has been obtained even when the combustion chambers of all the cylinders were tilted up and filled full of water previous to starting.

Many other functional problems had to be worked out. Control valves and other accessories had to be designed especially for the engine. Production methods were used wherever possible, so that when the prototype proved satisfactory, additional units could be manufactured as required.

REVIEWS

An Album of Celestial Photographs

(Published by the Author, A. L. Bedell, Box 1447, St. Louis 1, Min., U.S.A. $1.50, payable by International Money Order. 50 pp.)

Although the serious student of astronomy will find little here that is new to him, Mr. Bedell has brought together, for the astronomical dilettante, a fine collection of celestial photographs, mostly taken with the large telescopes of the Yerkes, Lick, Mount Wilson and Harvard Observatories. These photographs, intended to "simulate for every student the rare experience of looking through these giant instruments," in fact do more, by virtue of the long exposures photographically possible.

The selection of subject-matter is fairly well balanced, though it is probably inevitable that of 65 photographs taken with large instruments, 36 should be of nebulae. If criticism can be made, it is that no meteor photographs appear (presumably because they do not require a telescope), nor are there any prints of simple star groups such as the "double double" in Lyra, or the Trapezium of Orion, both of which would make attractive photographs. The three cometary photographs are ill-selected, as they do not show the wide diversity of form and interest of these bodies, and there seems little point in including both the globular clusters M.13 and ω Centauri, as both appear almost identical as reproduced, and one feels also that the eight photographs of the Moon are a little too much, even though of a good thing!

The reproduction is satisfactory on the whole, though in too many of the prints there is gross over-enlargement consequent upon endeavours to

make a good 3 by 2 inch into 11 by 8 inch. In particular, the well-known photograph of the Pleiades Nebulosity and an otherwise admirable prominence photograph have suffered badly in this respect. The composite photographs of the Milky Way are not worth reproducing, and the "close-up" of a sunspot is a poor example of its kind. The single photographs of Mars, Jupiter and Saturn might have been better selected, and one doubts the pictorial value of a crescent phase of Venus that is (perforce) completely geometrical in form and featureless in character. In contrast, the photograph of the Earth-lit Moon on the same page is unusual and pleasing, and many of the nebulae prints, in particular the "Horsehead" in Orion, the filamentary nebula of Cygnus, and the "Whirlpool" spiral in Canes Venatici, are truly excellent. Short descriptive notes are added in a preface—these are useful and might well be enlarged.

It is hoped that a future edition will see some of the defects mentioned overcome. In any case, the publisher is to be congratulated on having produced a volume that is a sound investment for anyone interested in the pictorial pleasures of the mother of all sciences.

M. W. OVENDEN.

Aviation Medicine

(By Ernst Jokl, published by Unie-Volkspers-Boekhandel, P.O. Box 90, Riebeek Square, Capetown, Union of South Africa. Price 10s. 6d. 213 pp. Illus.)

This interesting medical publication, written by the Consultant to the Director-General of Medical Services of the Union of South Africa, will be read with interest, as this is the first time such a book has been written in English on modern aviation conditions, giving very complete accounts of the ways in which the airman of to-day has to adapt himself to an ever-changing environment of faster machines, higher altitudes and longer flights.

The book will appeal not only to medical men, but to everyone interested in the physiology of flight, which has entailed an enormous amount of research in every country in the world, stimulated recently by the war.

There is an historical section, and four physiological sections, namely—altitude, speed and acceleration, blind flying and parachuting, with a fine chapter on the selection of air-crew personnel.

The layout of the book in general is good, though not conforming to English standards of printing. Some of the illustrations are good, but the majority have been spoiled by coarse reproductions from by no means original blocks.

Interplanetary flight will probably first be attempted without human occupants, and these test flights will not therefore entail the many vital physiological problems so necessary for human survival. When, however, interplanetary flight is so perfected as to carry personnel, many problems will have to be solved; the majority being of the type which the pioneers of modern flying encountered.

Dr. Jokl has explained in his book the development of the science of prevention both in the laboratory and in actual practice, of the numerous difficulties of greater acceleration and higher altitudes—all of which have been solved, some by bitter experience, the majority by careful forethought.

It is up to the medical men of to-day to train personnel and produce in the laboratories conditions which will ultimately enable man to make interplanetary flight a safe physiological possibility, for there will be no chance of trial and error experiments, as there has been in aviation.

Dr. Jokl, in his book, has done much to explain these problems and their solution. There is a very real need to go on studying these conditions; for example, of the sudden acceleration met with in catapulted aircraft and the problems which had to be faced before finding a solution—a very real condition which will be met with when the first man-occupied space ship is launched.

Dr. Jokl has done pioneer work in studying modern aircraft conditions, pioneer work which will ultimately be used for the first successful human interplanetary journey.

DR. A. HAYWARD.

Medical Aspects of Aviation

(By Capt. Ernst Jokl, M.D. Pp. 102. 10s. 6d. Sir Isaac Pitman & Sons Parker Street, Kingsway, W.C.2.)

If you are one of those old-fashioned people who spell it "aeroplane," you do not warm to those who persistently spell it "'plane." This is what Capt. Jokl does, from which the perspicacious may easily infer the character of his little book. It is frankly commercial journalism, and, strictly from that point of view, quite good value for the money. It would be even better if the crudely executed sketches of the Davos Research Institute, a hut on an alp, a "Puffing Billy," a string of mountaineers, and sundry other works of supererogation had been replaced by something more to the point. However, one can forgive a little padding when it includes a photograph of a horse standing on its nose, illustrating deceleration—and a drawing of an incredibly startled rabbit on a turntable (centrifuge experiments).

Chapter II—"A Short Excursion into Mechanics"—states that "angular accelerations include the practically most important accelerations produced during circular flying movements." The author must have meant "centripetal," not "angular." A certain Pilot McDonough, who dived an Airacobra at 600 m.p.h., is quoted, apparently with approval, as saying that if he had fired a pistol over the tail, the bullet would have rolled out of the barrel and fallen straight down! Even for a "popular," aimed at such as pilots and that patient sufferer the "intelligent layman," this is a bit too much.

Notwithstanding these puerilities, however, the author does succeed in presenting a good deal of simple practical information in palatable form. His observations on injuries are pertinent, and might have been amplified; it may be added that there is evidence that blows on the head causing laceration of the brain (without skull fracture) do so by virtue of the *rotary* accelerations induced. The reason is that brain substance is easily sheared, but, being mostly "incompressible" water, is little affected by direct stress. This may be worth bearing in mind in connection with head-rests, etc., in any vehicle or craft in which head injuries are possible.

On the whole, the book would be useful to those who want to acquire, rapidly, an idea of what aviation medicine is about. They will gain the

impression that it is about accelerations, oxygen lack, and "the bends," which are certainly the main branches, though not by any means the only ones.

DR. W. E. HICK.

Atoms, Planets and Stars

The Society has received a copy of the above wall-sheet by James Oliver Hogg, Jnr. of Burnham Buildings, Chicago, 1, Ill., U.S.A. (price $2.50). It is a 48 to 23 inch drawing representing, by various sketches, the structure of the Earth, the Earth and Moon, the solar system generally, with its relation to the nearest stars and the galaxy, and a description of some unusual stars. Also, rather incongruously, a simple table of elements, with their melting- and boiling-points, atomic weights and densities is included.

The first impression is that possibly the author, in the interests of conciseness, has become confusing. Surely, the relevance of the table of elements to the rest of the subject-matter is not immediately obvious to the beginner, for whom, presumably, the publication is intended. However, closer examination reveals much of value. The cut-section of the Earth showing its interior structure is unusual and informative; the diagrams showing relative distances in the solar system does give a vivid picture of the emptiness of space; and of special interest is an item called "Rocket Ship Time Table"—this is not the first interplanetary A.B.C., but is a table showing the distance from the Earth to the other planets and nearest stars in terms of travel times at various speeds.

The printing and paper are of the high quality that we have come to expect from transatlantic scientific publications, and the author has produced for display in school or study a useful quick-reference sheet for the student of elementary astronomy.

Development of the British Gas-Turbine Jet Unit

Published in War Emergency Issue No. 12 of the Institution of Mechanical Engineers, and reprinted for distribution in the U.S. by the American Society of Mechanical Engineers, Twenty-Nine West Thirty-Ninth Street, New York, 18, N.Y., U.S.A., are the series of lectures given at the symposium on gas turbines held by the I.M.E. in London last year. They are of great interest, not only from a purely technical viewpoint, but also in so far as they give an excellent impression of the scope of the work involved in perfecting this important new type of prime mover.

Combustion and Combustion Equipment for Aero Gas Turbines

This lecture was given before the Institute of Fuel on 28th May, 1947. Copies can be had from the Institute of Fuel, 18, Devonshire Street, W.1. Price 2s. each. The paper was read by Dr. E. A. Watson and Dr. J. S. Clarke.

The paper is very comprehensive and deals with many aspects of combustion applicable to jet engines. It is up to date and contains many diagrams and photographs of interest.

The final part of the paper is given to mechanical design features and choice of materials, and actual examples shown of the mechanical failure of flame tubes give some idea of the heat these parts have to contend with.

ABSTRACTS

Solar Spectroscopy at High Altitudes

Experiments were carried out by the U.S. Naval Research Laboratory at White Sands recently to measure solar radiation in the ultra-violet region, with the aid of a spectrometer mounted in a V.2 rocket. The work was directed by R. Tousey and C. V. Strain and results have been reported by the latter in the February, 1947, issue of *Sky and Telescope*.[1]

The object of the investigation was the examination of the solar spectrum in the region between 3,000 and 1,000 Angstroms, which is normally absorbed by the ozone in the atmosphere, but which should scarcely be affected at the high altitudes attainable by the rockets.

The spectroscope was built in a conical assembly, and mounted apex forward in a well in one of the V.2 fins. The spectroscope was a double, i.e. it formed two spectra, though it used only one diffraction grating. Lithium fluoride was used in some of the optical parts, on account of its high transmission in the ultra-violet region. Two beads of lithium fluoride, acting as lenses, were mounted diametrically opposite each other about half-way down the cone. Each bead focused the solar radiation on a slit fitted with a motor-driven rotating shutter, the light passing thence on to a plane mirror which directed the rays on to a reflection grating in the apex of the cone. The grating, ruled with 15,000 lines per inch and having a radius of curvature of 40 cms., focused the rays from each shutter on to a 35-mm. film at the base of the cone. Thus, the main parts of the instrument were two lithium fluoride beads, two shutters, two plane mirrors and a single grating, and these formed two spectra which were recorded side by side on the film. The object of this duplication was to increase the chance of obtaining *some* records, despite the yawing and rolling of the rocket.

The shutters were driven in such a manner as to give cycles of exposures of 1/10th, 6/10ths and 3 secs., during the first 150 secs. of flight. After each exposure the film was moved forward and, in doing so, operated a micro-switch which caused a radio pulse to be transmitted from the rocket. Subsequent correlation of the times of pulses with observations of the V.2 trajectory permitted the determination of the altitude corresponding to each exposure. The film was to be stopped for 100 secs. at the top of the trajectory to enable a long exposure of 55 secs. to be made. After the long exposure the film rolled into a cassette,[2] designed to withstand the high landing shock. As a further precaution against damage to the instrument on landing, an explosive charge was placed in the nose of the rocket to bring about the disruption of the nose, so affecting the ballistics in such a way that the landing velocity was reduced considerably (in normal circumstances the landing velocity might well have been as high as 4,000 ft./sec.).

The V.2 was fired at White Sands on 16th October, 1946, and the spectrometer was subsequently recovered almost undamaged. Examination of the film showed that exposures had been made up to 88 kms. altitude, but the film had advanced too far in the early exposures and had run out before the 55-sec.

exposure could be made, so that the latter was missing. The 88-km. exposure was weak owing to the rolling of the rocket moving the spectrometer right out of line with the sun. Good records were only available, therefore, up to 55 kms.; they showed strong radiation, down to 2,925 Angstroms at 25 kms. and down to 2,650 Angs. at 34 kms. There was still sufficient ozone above 34 kms. to obscure the 2,550 Angstrom Hartley-band, but at 55 kms. this radiation was strongly evident. A more detailed analysis of results was still in progress when this report was made.

REFERENCES.

(1) *Sky and Telescope* is published by Sky Publishing Corporation, Harvard College Observatory, Cambridge, Mass., U.S.A. It is a high-quality, semi-technical periodical written mainly for the amateur astronomer. It appears monthly, and contains articles of topical interest in the field of astronomy. Star charts and observational data are published each month and recent copies have included a series of full-page photographs (on the back cover) of sections of the lunar surface—a key to the various formations being given. There are frequent reports on the V.2 experiments carried out at White Sands.

(2) Details of the "rugged" film cassette were reported by J. W. Forrest in *The Educational Focus*, a publication of the Bausch and Lamb, Optical Co., Rochester, New York.

The Rate of Descent of Parachutes from Various Altitudes

(By K. E. Penrod, G. L. Maison and J. E. McDonald, May, 1947, *Journal of the Aeronautical Sciences.*)

This paper presents a method of calculating the velocity at any instant of a parachute descent. Data on which it is based were obtained from tests with three different parachute types (24 and 28 feet diameter nylon and 28 feet diameter silk) from various launching altitudes up to 40,000 feet, using 200-lb. dummies.

Les Problèmes Physiologiques Posés par la Propulsion par Réaction

(Médicin-Commandant R. Lemaire. *Espaces, No.* 11, December, 1946.)

The problems briefly discussed in this article are not peculiar to "the propulsion by reaction," except in so far as that is the only known method of reaching speeds measured in Mach units. It is, as the author implies in his preamble, the coming thing—"in all the countries, one constructs the prototypes." One does, indeed: and, as he further remarks, one fabricates the machine, and the pilot makes of it the test, and if he should test himself to destruction, much honour to him. In other words, the médicin-commandant wishes to make it clear that if you want to get about in the atmosphere in the super-sports manner, you have to take certain precautions.

An unusually brief reference to black-out (*voile noir*) reminds the reader, among other things, that the pilot cannot rely on being able to adjust his radius of turn, or other manoeuvre, according to his sensations; owing to the time-lag in the physiological processes, the "black veil," or even unconsciousness, may persist after the acceleration has dropped far below the value which produced it. Moreover, shortage of oxygen progressively lowers the pilot's resistance to the effects of acceleration, cold and fatigue.

As a particular cause of fatigue, the author mentions that the necessity of avoiding "brutal evolutions" leads to "pilotage par pression." This means tensing all one's muscles, in order to make extremely small movements of the controls. This may, of course, result from over-anxiety in the pilot, but otherwise it is due to undesirable control characteristics, especially static combined with extreme sensitivity. The over-anxiety may be produced by friction disturbances, such as gusts or the instabilities arising at sonic speeds, which require the pilot's constant attention, and lead to "fatigue psychique."

At speeds in the sonic region, it is also necessary to beware of the effects of shock waves on the pilot's respiratory system, which, as the author points out, may be fatal. Dangerous falls in pressure also arise in rapid ascents, producing "phénomènes excito-moteurs" (presumably the bends), gas in the abdomen, and a lowered resistance to anoxaemia. And so on. These troubles, of course, can be eliminated by having a "cabine étanche," which is all right until it springs a leak and stops being "étanche." Without doubt, as the worthy doctor says, we find ourselves in front of conditions peculiar!

Astronomical Observations from the Moon

In a recent paper (Leaflet No. 219—May, 1947, Astronomical Society of the Pacific), Dr. R. S. Richardson has discussed the advantages of a lunar observatory. "Seeing" would be far better than on Earth, and perhaps most important the whole of the spectrum would be available to the astronomers. The Earth's atmosphere becomes practically opaque just below the ultra-violet, and thus blinds us to some of the most vital information about the stars.

However, it would not be possible to obtain a great increase in space-penetration since long-exposure photographic plates would still be fogged by the zodiacal light (which causes about 60 per cent. of the background light in the Earth's sky). We will have to go beyond Jupiter to eliminate this!

Dr. Richardson makes the point that lunar telescopes, unlike terrestrial ones, cannot have fixed polar axes if they are to be used for long exposures. The Moon's axis precesses through a complete circle in only 18·5 years, as compared with the Earth's 26,000 year period. "Compensating for this motion of the lunar axis would furnish the engineering staff with a highly interesting problem."

Further Astronomical Radar Observations

B.A.A. *Circular* No. 285, 1947, September 18, contains two reports of interest, both from the Jodrell Bank, Manchester, Radar Research Group, under Dr. A. C. B. Lovell.

The first report is of the cessation of the daylight meteor shower reported in *Circular* No. 282 (see *J.B.I.S.*, 6, 179, September, 1947). The Pisces radiant was joined, on June 18, by a second radiant further east in Gemini, and both radiants remained active until the end of July, when they began to fade and disappeared by mid-August. The remarkable stream had lasted for a quarter of a year.

Secondly, echoes are reported received on the 46 Mc./s. and 72 Mc./s. equipment from the Aurora of August 15. They started simultaneously with

the appearance of a faint auroral cloud at the zenith, and disappeared sharply when this cloud was seen to break into striations. The range of the echoes, which, since the cloud was at the zenith, is, presumably, the height of this phenomenon, was 480 Km. In order to produce the echoes the electron density in the cloud must have been of the order of 5×10^7 electrons/c.c., some 100 times greater than the normal nocturnal density at such an altitude.

Liquid Propellant Rocket Power Plants

This lecture, by Dr. M. J. Zucrow, late of Aerojets, and now of Purdue University, Lafayette, Indiana, was presented to the Aviation Division of the American Society of Mechanical Engineers at their semi-annual meeting on 16th–19th June, 1947. Pre-prints were published then, but the paper will appear in the A.S.M.E. Journal later.

In a general survey of the subject, some interesting graphs were given showing specific impulse, density impulse, chamber temperature, mean molecular weight and specific heat ratio, plotted against mixture ratio for many different propellants.

The problem of attaining escape velocity was discussed, with reference to the Paris paper of Malina and Summerfield (*The Problem of Escape from the Earth*, GALCIT Jet Propulsion Lab. Publication No. 5, 23rd August, 1946). It was concluded that a 10-step rocket burning liquid hydrogen and oxygen, and having about twice the take-off weight of V.2, could just attain escape velocity with 100 lbs. payload. It is interesting to note that Dr. Zucrow conservatively assumed a structural factor for hydrogen/oxygen rockets which was 30 per cent. worse than that suggested by Malina. It may be remembered that this question was raised in the discussion when Dr. Malina spoke to the B.I.S. last year. With the very low density of liquid hydrogen, it would be extremely difficult to build a light rocket, because of the large tank volumes required.

Dr. Zucrow thought that the prospect of any really large future increase in specific impulse from chemical fuels was not very hopeful. If two or three times present values were needed, we should probably have to await the application of new forms of energy (e.g. atomic). However, some improvement would be possible if higher chamber pressures could be used, and insufficient attention had been devoted to this in the past.

Mention was made of the experimental work of the Analysis Division, Intelligence T.2, Rocket Unit at Wright Field (U.S.A.). A dural chamber with highly developed film cooling had been run for 3 to 4 hours with a pressure of 600 lbs./in.^{2} The action of film cooling was threefold:—

(*a*) The film itself was a bad conductor.

(*b*) With hydrocarbon fuel, it deposited a carbon layer of about ·030 inch thickness which also helped with heat insulation.

(*c*) It absorbed heat due to its latent heat of vaporisation.

Ultimately, it might be possible to run at 1,500 lbs./in.^{2}, even at high temperatures.

Supersonic Aerodynamics—Principles and Applications

The 10th Wright Bros. lecture was delivered by Dr. Theodore von Kármán before the Institute of Aeronautical Sciences in April, 1947, and has been reprinted in their July, 1947, *Journal*. This admirable paper gives a very comprehensive survey of its subject and is worthy of careful study by all who claim an interest in rocket flight. Its general style is indicated by the author's introductory remarks: "I believe we have now arrived at the stage where knowledge of supersonic aerodynamics should be considered by the aeronautical engineer as a necessary prerequisite to his art."

Artificial Meteors

(By Dr. F. Zwicky, *Ordnance*, July–Aug., 1947, Vol. 32, No. 163, pp. 18–20, illustrated.)

Dr. Zwicky, who is Prof. of Astrophysics at the California Institute of Technology, states that rocket research is being planned along the following lines.

(1) Large primary rockets, e.g. V.2, to carry scientific instruments to great heights to investigate the properties of the upper atmosphere and radiations from celestial bodies.
(2) Secondary rockets to be launched from primaries and designed to reach heights of 500–1000 kms.
(3) Missiles capable of escape from the earth's gravity. Here there are three possibilities:—
   (*a*) Use of nuclear energy.
   (*b*) Step rockets using chemical energy.
   (*c*) Ejection of fast, small particles from shaped charges carried in rockets.

This latter method has not so far been properly investigated. Explosion of a properly shaped charge is capable of generating sufficient energy to produce these fast-flying particles. Information may be obtained by means of them in the following fields:—

(1) Supersonic aerodynamics up to Mach numbers of about 50.
(2) Physical and chemical characteristics of the atmosphere at extreme altitudes.
(3) Possibly some information on conditions in space.
(4) Investigation of electromagnetic fields at great heights. Optical methods of observation will be used to a great extent.

A programme using rifle grenades inserted in the V.2 instrument head has been organised. The first night test on 17th December, 1946, was unsuccessful, due to non-ignition of the charges, but further tests are planned. Charges to give the maximum velocity to the particles are being designed—10 to 15 km./sec. are hoped for.

Acknowledgments

The Librarian begs to acknowledge with thanks receipt of *Electronic Devices and their Application* (Anderson), kindly donated by Mr. L. McGuigan, and *Gas Turbines and Jet Propulsion* (Smith), kindly donated by Mr. E. M. Waine.

NOTES AND NEWS

Secretarial Address

The attention of all members and correspondents is drawn to the new secretarial address at 157, Friary Road, London, S.E.15, to which all future communications should be addressed.

Translations

The Deputy Technical Director dealing with Bibliography would be very pleased to welcome assistance from members who might care to help in translating material from foreign languages into English. Assistance is required in dealing with nearly every foreign tongue. Interested members should write to G. V. E. Thompson, 31, Brooklands Gardens, Gidea Park, Essex.

Super Altitude-Research (Neptune) Rocket

Details of the design and estimated performance of the Martin-built Neptune rocket are given in *Aviation*, 46 (1947), 6 (June), pp. 40-3 (Smith, C. H. Jnr., Rosen, M. W., and Bridger, J. M., with illus. and tabs.). This is a new high-altitude research missile being built for the U.S. Navy with which it is hoped to reach heights of over 200 miles. The main characteristics of Neptune are given in Table I and performance estimates in Table II. The power plant is a single combustion chamber liquid oxygen/alcohol rocket motor to be made by Reaction Motors Inc. A turbo-pump propellant injection system is used due to the low weight of the installation compared with a pressure feed system. Straight alcohol is being used with commercial liquid oxygen at a mixture ratio of 0·9 to 1·0, alcohol to liquid oxygen, and a specific impulse of 210 secs. is hoped for at ground level. (*Note.*—The theoretical S.I. for ethyl alcohol/oxygen at this ratio and a combustion chamber pressure of 20 atmospheres is 224 secs.) The rocket motor is started by a standard pyrotechnic igniter.

An interesting feature is the provision for alteration of thrust direction by means of moving the complete chamber through a small angle. This method has been chosen in preference to the use of vanes in the jet-stream as a saving of 275 lb. wt. is achieved, and in addition thrust loss due to the vanes is eliminated. Roll correction is provided for by releasing the peroxide turbine exhaust from roll jets at a distance from the longitudinal axis and in a direction to provide the necessary moment. Valves are operated by the error correction signal so as to increase the steam exhaust on the side opposing the roll.

The space in Neptune is utilised as follows:—

Nose to 77 in. station:	research instruments.
77 in. to 120 in. station:	flight control instruments.
120 in. to 437 in. station:	propellant tanks, oxygen forward, alcohol aft; the alcohol tank is integral with the rocket structure.
437 in. to 543 in. station:	turbo-pump assembly, peroxide tank, rocket motor and hydraulic equipment.

TABLE I

NEPTUNE CHARACTERISTICS

Dimensions:	
Length	543 in.
Diameter	32 in.
Span (across fins)	98 in.
Weight:	
Total empty wt.	1,992 lb.
Propellants (alcohol, oxygen, H_2O_2 and He)	7,418 lb.
Payload	100–2,000 lb.
Total gross wt.	9,510–11,410 lb.
Performance:	
Altitude	1,255,000 ft.
Velocity (max.)	8,200 ft./sec.
Time to max. altitude	335 secs.
Acceleration (max.)	10·87 g.
Thrust (max.)	22,900 lb.
Specific impulse (max.)	242 secs.
Duration of thrust	75 secs.
Propellants:	
Alcohol	3,380 lb.
Liquid oxygen	3,760 lb.
Hydrogen peroxide	270 lb.
Helium (for pressurising)	8 lb.

TABLE II

COMPARISON OF NEPTUNE AND V.2 PERFORMANCE

	Neptune				V.2
Payload (lb.)	100	500	1,000	2,000	2,200†
Max. altitude (ft.)	1,255,000	1,006,000	733,000	446,000	600,000*
Alt. at burnout (ft.)	189,000	172,000	150,000	118,000	100,000*
Burning time (secs.)	75	75	75	75	67*
Max. velocity (ft./sec.)	8,200	7,260	6,070	4,570	5,200*
Total weight (lb.)	9,510	9,910	10,410	11,410	28,380†
Propellant wt. (lb.)	7,140	7,140	7,140	7,140	19,613†
Thrust (sea level) (lb.)	20,000	20,000	20,000	20,000	52,200†
Max. acceleration (g.)	10·9	8·8	7·3	5·6	6*

* Values obtained from V.2 firings at White Sands Proving Ground.

† Derived from German V.2 literature.

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ASTRONOMICAL NOTEBOOK—2

By M. W. Wholey

The 200-inch Reflector

The 200-inch reflector on Mount Palomar, California, has remained something of a mystery to most of us for many years, for in all, very few facts have been published for general consumption.

Here, therefore, are a few collected from various sources, which may be of interest to members of the Society.

The Mirror

The first intention was to form the mirror of quartz, and to this end General Electric carried out many experiments. Two 60-inch discs were attempted. Both failed, due to unfortunate circumstances which did not lie in the fault of the quartz at all—the first was a failure of the electricity supply and the second due to part of the furnace lining falling on to the molten surface.

They then turned, as one authority puts it, to "Faith, Hope and Pyrex," at the Corning Glass Works.

In the course of the work—which resulted in a perfect 200-inch disc—the attempts were as follows:—

A 26-inch test disc was perfect at a first attempt. Then the first of the discs to be used—a 36-inch ribbed disc for the Coudé Chain—failed at the first attempt as the cores broke loose, the second cracked on cooling, but the third was good enough for use. A 60-inch disc for the Cassegrain Chain was completed in two attempts, during which trouble was encountered due to escaping cores. The 120-inch disc, which was to end as the optical test flat for the big reflector, was perfect at the first attempt, due to the experience gained in making the previous smaller discs. Then, in an atmosphere of great tensions, the 200-inch main disc was attempted for the first time. Some cores floated loose. The disc, however, was used in experiments to verify the new theory of cooling worked out by the glass technicians. It was perfect. Experimental results checked with the calculated values.

The second try was absolutely successful. Unground, it weighed 20 tons and required nine months for the cooling, during which it had to survive serious floods from the nearby river, necessitating a dismantling, at a crucial moment, of the power plant supplying it with heat. An earthquake also added to its tribulations.

After grinding and polishing, all the mirrors were aluminiumised instead of receiving the usual silvered finish of the older mirrors. In fact, in the course of experimenting with methods of depositing the aluminium, the mirrors of the 100-inch equipment at Mount Wilson were coated most successfully.

The Telescope Structure

The mirror cell, which weighs 19 tons, was used as the turntable for the grinding process, and was manufactured at the same time as the yoke, tube and horsehoe. These constitute the moving parts of the telescope and together weigh 425 tons!

The side arms of the yoke are cylinders 10 feet in diameter and 47 feet long. Welded from steel, 1 inch thick, they have a cross-piece consisting of a box girder 46 feet long and nearly 11 feet deep. Small laboratories have been built into these arms.

The tube is constructed mostly of half-inch plate and the main structure is 22 feet square and 44 feet long, weighing 64 tons.

Attached to the ends of the yoke is the horseshoe—over 150 tons of steel plate varying from 4½ inches thick to a mere inch. It was made in three parts to facilitate transport.

Power for the telescope is supplied by three small generating units mounted on huge concrete blocks, which, in order to prevent any vibration from affecting the dome instruments 1,000 feet away, are mounted on springs at each corner.

Current-control equipment, as used in the Boulder Dam, maintains, within 1 per cent., 60 cycles per second for the driving mechanism and clocks.

The dome is rotated by the rolling action of two truck wheels complete with tyres, pressed against a band circling the dome.

Accuracies

Considering the immense bulk of the telescope the accuracies achieved were remarkable. Here are a few:—

Their greatest error in 44 feet in the tube was 1/32nd of an inch. The horseshoe was machined as an ellipse only 1/20th of an inch from a true circle, 46 feet in diameter and 4 feet thick, to compensate for distortion. For all positions of the tube, the deflection in alignment of the centres of the end-rings never exceeded ⅛rd of the specified allowed error of 8/100ths of an inch. The centres were 44 feet apart. The driving gears, each 14 feet in diameter, were machined so that all teeth in both gears were identical to within a quarter of the allowed 4/10,000ths of an inch machining error.

It is expected that the new instrument will be ready for use early next year.

Errata

On page 148 of the June, 1947, *Journal*, the nozzle efficiency (η_n) was defined as "the ratio of the exhaust velocity with friction to that without friction." This should have read, "the square of this ratio," as is apparent from the use of η_n in equation (4) on page 131.

On page 50 of the May, 1947, *Bulletin*, T-stoff was quoted as "80 per cent. hydrogen peroxide with 1–2 per cent. oxyquinoline." The oxyquinoline content should have appeared as ·3 grm./litre (·03 per cent.).

The Nature and Distribution of Meteoric Matter (September, 1947, *Journal*):—

On page 168, line 25, for $(\sqrt[5]{100})^{y'}$ read $(\sqrt[15]{100})^{y'}$.

On page 168, line 29, for "4" read "approx. 5¼."

On page 168, Table III, column headed "Visual Magnitude" should read, downwards, $-6\frac{1}{2}$; -4; $-1\frac{1}{2}$; $+1$; $+3\frac{1}{2}$; $+6$; $+8\frac{1}{2}$;

CORRESPONDENCE

SIR,

Lunar Meteors

At the meeting of the Society on 3rd May last, discussion turned to the much-debated question of lunar meteorites. It is well known that the Earth is continually subjected to bombardment by meteoric particles that dissipate their energy in the Earth's atmosphere, causing the familiar "shooting star." The Moon must likewise be subjected to such a bombardment, and it is surprising that no conclusive evidence of the impact of meteors on the lunar surface has ever been reported.

If, as is usually the case, it is assumed that the moon has no protective atmosphere, the direct impact of a meteor with the lunar surface should, for the higher-energy meteors at least, give rise to a flash of light-energy capable of being seen from the Earth. It is true that the Earth gives some measure of geometrical and gravitational shielding, but nevertheless some flashes should be observed; La Paz has calculated[1] that on a totally atmosphereless Moon there would be produced 100 impact-flares each year bright enough to be visible to the *naked eye* from the Earth on the non-sunlit part of the Earth-turned lunar hemisphere. The number telescopically observable should be very much greater, and the almost complete absence of any such reported observation is surprising. However, such an observation, of very transitory nature and perforce not susceptible to confirmation by others, might well deter many an observer from public announcement.

Some systematic work with the express intention of detecting the effects of lunar meteors has been performed, and has been extended and analysed recently by W. H. Haas[2]; in all, the work covers 65¾ hours of observing-time. Absolutely *no* flashes of meteoric impact were observed during these periods; instead, ten moving luminous specks were observed; the length of the paths were of the order of 1 second of arc. Haas gives a critical examination of possible explanations for these observations, and comes to the conclusion that some of these specks may have been luminous paths of meteors in a tenuous lunar atmosphere. Crommelin has pointed out[3] that even a very tenuous atmosphere would, by virtue of the lower surface gravity of the Moon, and consequent smaller density gradient in the lunar atmosphere, provide an effective shield against meteoric impact. It has yet to be demonstrated that an atmosphere sufficiently dense to provide such a shield, and capable of giving luminous meteor trails, would have remained otherwise undetected, but it appears from Haas' calculations that the number of streaks observed is of the expected order of magnitude. Further careful observations[4] are needed before any decision can be made, but at any rate there is a possibility that such an explanation may solve the problem of the hitherto almost complete absence of any detection of possible effects of lunar meteors.

M. W. OVENDEN

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(1) L. La Paz, *Popular Astronomy*, **46**, 277, 1938.
(2) W. H. Haas, *ibid.*, **55**, 266, 1947 (May).
(3) A. C. D. Crommelin, *Splendours of the Heavens*, **1**, 244, 1923.
(4) F. H. Thornton, *Things do happen on the Moon*, J.B.A.A., **57**, 143, 1947 (March).

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